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van Hemert, P.P.; Nijkamp, P.; Verbraak, J.E.

2009

document version
Early version, also known as pre-print

Evaluating social science and humanities knowledge production: an exploratory analysis of dynamics in science systems

Patricia van Hemert*
VU University Amsterdam
VU Center for Entrepreneurship
De Boelelaan 1085
1081 HV Amsterdam
phemert@feweb.vu.nl

Peter Nijkamp
VU University Amsterdam
Department of Spatial Economics
De Boelelaan 1105
1081 HV Amsterdam
pnijkamp@feweb.vu.nl

Jolanda Verbraak
VU University Amsterdam
VU Center for Entrepreneurship
jverbraak@feweb.vu.nl

* Corresponding author

Abstract

Knowledge is gaining increasing importance in modern-day society as a factor of production and, ultimately, growth. This paper explores the dynamics in university knowledge production and its effect on the state of university-industry-policy exchange in the Netherlands. Science systems are said to be in transformation. The university has evolved from performing conventional research and education functions to serving as an innovation-promoting knowledge hub; dynamics that have received mixed reactions. Social Sciences and Humanities (SSH) assume a special position, insofar that their focus seems primarily on conventional research and education functions, and not directly on (commercial) valorisation. Societal changes are, however, pressing for a reconsideration of the role of SSH. In our paper we distinguish between three important new movements that seem to affect SSH. It is believed that these movements that already have some impact today will considerably influence SSH in the future. These developments are: further differentiation, synthesis between the various sub-disciplines of SSH and natural sciences, and shifts in paradigms. The aims of this paper are twofold: 1) assess what is believed to be a most likely development of SSH by means of discovery of relevant subsets of factors influencing university knowledge production; and 2) discover whether the knowledge production factors show characteristics of a general development similarly to the 'Mode 2' concept introduced by Gibbons et al. (1994). By means of 22 semi-structured personal interviews with key representatives from the business, university and the policy sector, a systematic qualitative database was created. Our explanatory framework employs an artificial intelligence method, viz. rough set analysis. On the basis of these results, we find that a small minority of the respondents prefers a closer relationship of SSH with society, government and industry, and other institutional centers of authority, while in particular interdisciplinarity is regarded as having an overall positive influence on the future of SSH in the Netherlands. Consequently, the idea of a clear distinction between Mode 1 and Mode 2 knowledge production, i.e. traditional knowledge and knowledge carried out in the context of application is not supported by our data.

Key words: science systems, knowledge production, Mode 2, SSH, rough set analysis, artificial intelligence

1. Introduction

Changes in society are taking place with an ever-increasing speed and due to further complexity of the system the need for innovative but also reflective knowledge production is becoming more demanding. Although knowledge production is realized both on a public or private level, higher education institutions and especially universities are generally considered prime knowledge production functions. Due to the dynamics and demands of modern society, their role is becoming more all encompassing. There is increasing focus on technological and other forms of innovation, productivity and economic growth, which cannot be achieved without a highly educated population, public- and industry-funded research and new and superior products and processes. At the same time, the complexity of advances intensifies the need for reflection, in order to avoid overvaluation or even recklessness. The current situation in the financial sector can only serve as an example here. Further, due to the speed of change, there is a growing demand from society for reflection on the processes of change. This puts large pressure on science systems. The university seems to have evolved from performing conventional research and education functions to serving as an innovation-promoting knowledge hub. This development is, according to some, in line with the dynamics taking place in society and is therefore natural and inevitable, while others are of the opinion that such a movement will harm the fundament of the science system, i.e. curiosity driven research. Science systems form the basis of our knowledge economy, yet, at the moment, there is wide disagreement on its future. In this paper, we aim to shed some further light on the perceptions that exist about modern science systems and their future, with the idea of adding to this discussion and increasing its transparency for policy makers and the likes.

The claim that the content of scientific research agenda is currently changing is becoming more and more prominent in recent literature. The majority of publications address a turn towards more relevant research, research that (sooner or later) may lead to applications in the form of innovations or policy. According to a recent report by the European Science Foundation (2008), higher education as a result increasingly feels itself under pressure to cope with a growing range of expectations, which are viewed as demanding and conflicting. A variety of approaches to understand, explain and perhaps extrapolate such trends have emerged, of which the most famous account of a transformation is the concept of ‘Mode 2’ knowledge production that is introduced in *The New Production of Knowledge* (Gibbons et al., 1994). While knowledge production used to be located primarily in scientific institutions and structured by scientific disciplines, the book argues that its locations, practices and principles are now much more heterogeneous. Mode 2 knowledge in this respect supplements Mode 1 knowledge. In Mode 1, knowledge production is carried out in the absence of a particular goal with quality control maintained essentially through peer review. Mode 2, on the other hand, is viewed as a transdisciplinary, heterogeneous and hierarchical method that achieves quality through social accountability and reflexivity, leading to results that are highly contextualized. Contrary to the current literature, however, in this paper, we base ourselves not on the Gibbons-Nowotny notion of ‘Mode 2 knowledge production’, but on a systematic reflection of this approach by Hessels and van Lente (2008). In this paper, they propose to untie the wrapping around the Mode 2 concept. The Mode 2 claims have received mixed reactions: hundreds of papers cite *New Production of Knowledge* affirmatively and policy makers use the arguments, but there is also serious criticism.

Curiosity-driven research or basic research is motivated by the desire to seek new understanding and knowledge about nature, while use-driven or applied research is motivated by

the desire to use that knowledge in a practical way. Already in 1959, Snow stated that the research process essentially has two motives: one is to understand the natural world; the other is to control it. This implies that elements of Mode 2 have always existed in modern science; a view that has been highlighted by various academics (Rip, 2000; Etzkowitz and Leydesdorf, 2000; Pestre, 2003). Etzkowitz and Leydesdorf (2000) even believe that not Mode 1 but Mode 2 is the original format of science, as, in the 17th century, research focused primarily on practical problems. Hessels and van Lente acknowledge this deeper complexity of the science system. By means of a literature analysis, they find a list of seven objections, which show that especially the linear historical perspective, the generality of the arguments and the necessary coherence of the original Mode 2 arguments are problematical. They therefore suggest a re-thinking of new knowledge production by addressing in particular three empirical questions: 1) Do transdisciplinary research activities, with a dynamic integration of theoretical and practical components from various disciplines, constitute a substantial part of contemporary science systems?; 2) Are university scientists in general increasingly reflexive, in the sense that they are aware of the potential societal effects of their research and take these into account in their choice of research objects, methods and approaches?; and 3) Do new criteria, relating to the societal relevance of research results, currently count significantly in all types of scientific quality control, not only in funding allocation, but also in retrospective evaluations of individuals, projects or organizations? Hessels and van Lente, further, strongly advise scholars addressing these three questions to take into account the heterogeneity of science, paying attention to the differences between scientific fields and national contexts.

Due to the heterogeneity of scientific practice, the emergence of new modes of knowledge production will not have the same impact in the whole science system. Its importance may vary in national contexts (Shinn, 2002) and in scientific disciplines (Albert, 2003). According to Hessels and van Lente, it is therefore important that further research shows how visible the various Mode 2 attributes are in different disciplines and in different countries. With our research, we attempt to take a first step towards disconnecting the five major constitutive claims and investigating them separately. We focus in particular on the future movements of the disciplines SSH in the Netherlands, but with the broader aim of getting a view on the future of universities. We focus on SSH because these disciplines appear to suffer most visibly from the changing role of universities into an innovation-promoting hub. Aim of the paper is to predict what is believed to be a most likely development of SSH by means of discovery of relevant subsets of factors influencing university knowledge production, which will be loosely based on the attributes of Mode 1 and Mode 2 knowledge production. By means of 22 semi-structured personal interviews with representatives from the business sector, university and the policy field, a systematic qualitative database was created. The explanatory framework employs an artificial intelligence method, viz. rough set analysis, which is a quantitative exploratory correlation analysis for small samples.

We will start our paper with a description of what we believe are the three most likely future developments of SSH. These three movements will be compared and connected to the concepts of Mode 1 and Mode 2 knowledge production according to Hessels and van Lente (2008), and will serve as the foundations for our analytical model. Next, the design of the analytical model will be further explained, taking into account the criticism put forward by Hessels and van Lente. This will be followed by the presentation of the outcomes of the rough set analysis and the interpretation of its results. In the conclusion, then, we hope to be able to make some predictions with regards to the future movements of SSH by means of the relevant

subsets of factors influencing university knowledge production. At the same time, we hope to shed some light on the three empirical questions posed by Hessels and van Lente for SSH in the Netherlands. Although we will not be able to answer these questions directly, we do think that our results may offer some useful material for further definition of new knowledge production and of the university knowledge system.

2. Movements in SSH science systems

2.1 Introduction

The recently published future outlook on higher education by the European Science Foundation (2008) discusses the growing range of demanding and conflicting expectations that higher education is currently faced with. In the study five tensions with respect to the relationships between higher education and society are considered to transcend the individual fields and the individual functions of higher education and as a result deserve attention in future higher education research. The first tension deals with the demand for increasing visibility towards economy and society of higher education, which may come at the cost of characteristic features towards other knowledge institutions. Second, higher education is expected to gain from inter-institutional diversity, while at the same time it is expected to increase intra-institutional diversity. Third, higher education is viewed as being more successful when the individual institution acts strategically, but strategic coherence is constantly challenged by the broad range of ever-increasing expectations. Fourthly, established borderlines of arenas get blurred in the process of internationalization and globalization, but this also reduces protection from and heightens visibility to external demands. Finally, higher education is facing increasing tensions in relation to its role of reinforcing or changing the social order in which it is embedded. The study further points out that research on higher education will need to identify how higher education is handling these tensions and conflicts by identifying how the societal role of higher education, behind the key functions of generating and disseminating knowledge in various disciplines and cross-disciplinary areas, is shaped or shapes itself in societies which have considerably changed in the advent of the knowledge society, the strengths of competitive settings and of managerial power. Basing ourselves on the five tensions described by the European Science Foundation, we believe that three important new movements can be distinguished that seem to affect higher education. These developments are: further differentiation, synthesis between the various sub disciplines, and paradigm shifts. In line with the future outlook, we support the universality of the movements; however, due to contrasting contexts and settings for comparative investigation between countries and disciplines, we have chosen to limit ourselves to a description of movements in the areas of SSH in especially the Netherlands. The three developments will now each be discussed separately.

2.2 Further differentiation of SSH

According to the European Science Foundation (2008), higher education is widely conceived as acting most successfully if inter-institutional diversity grows both vertically, i.e. through institutions and departments characterized by distinct levels of quality in steep hierarchy, and horizontally, i.e. through distinctive profiles of individual institutions and departments.

Although there is a great deal less of that grand or comprehensive theory that was a hallmark of 19th-century social philosophy and social science, there are still those persons occasionally to be found today who are engrossed in search for master principles, for general and unified theory that will assimilate all the lesser and more specialized types of theory. But their efforts and results are not regarded as successful by the vast majority of social scientists. Theory, at its best, today tends to be specific theory—related to one or other of the major divisions of research within each of the social sciences. The theory of the firm in economics, of deviance in sociology, of communication in political science, of attitude formation in social psychology, of divergent development in cultural anthropology are all examples of theory in every proper sense of the word. But each is, clearly, specific. If there is a single social science in which a more or less unified theory exists, with reference to the whole of the discipline, it is economics. Even here, however, unified, general theory does not have the influence it had in the classical tradition of Ricardo and his followers before the true complexities of economic behavior had become revealed. Overall, there is a growing diversity within the social sciences and humanities, in terms of content, methods, institutional loci, links with professions and communities of practices, etc. Specialization has been as notable a tendency in the social sciences as in the biological and physical sciences. This is reflected not only in varieties of research but also in course offerings in academic departments. Whereas not very many years ago, a couple of dozen advanced courses in a social science reflected the specialization and diversity of the discipline even in major universities with graduate schools, today a hundred such courses are found.

2.3 Synthesis between various sub-disciplines of SSH and natural sciences

On the other hand, institutions and departments seem to be expected to be more multifunctional than ever with established borderlines of arenas and functions getting blurred as a result of increasing internationalization and globalization. Alongside this strong trend toward specialization, then, is another, countering trend of cross-fertilization and interdisciplinary cooperation. It seems clear that to explore the socio-cultural foundations of economies rigorously and methodically, one must draw on the other social sciences. Take anthropology, for example. It is a discipline which can attempt to explain the influence of value systems, institutions, family structures and even religious backgrounds on the behaviour of individuals. But for many years, anthropology and its related offshoot of ethnology were confined to the study of exotic societies. However, it can also throw light on the functioning, if not the future, of our own societies. Apart from the multi-disciplinary qualities of the social sciences themselves, there is also the proposition of a closer relationship between the social sciences and natural sciences. There is already an overlap as a result of what is happening in the development of neuro-sciences: for example, research centres in this discipline have biologists, doctors, psychologists, sociologists, mathematicians and philosophers working closely together. Another example features the quality of the environment, the availability of natural resources, and even the productivity of marine environments: all are strongly influenced by human, or anthropogenic, factors. Now, world-wide programs conducted in fields such as the study of global warming bring researchers in natural and human sciences together at the same table. There is no question that the demand for people who have been well trained in both types of science will increase from now on, and academic programs will have to be introduced to meet this need. Also, there is every reason to believe that social sciences and humanities will be transformed - maybe more so than natural sciences - by advances in information technology and the ability to collect, process, stock and disseminate

enormous quantities of data. It is beginning to be possible to link existing data bases in many fields in different countries, and to carry out large-scale, integrated, comparative analyses. Huge surveys can now be conducted on an extensive range of subjects on the internet, which is clearly helpful in studying the perceptions and behavior of a wide variety of people. And IT has opened up the possibility of working in virtual laboratories that link up large numbers of research teams on a worldwide network.

2.4 Changing paradigms for SSH Futures

Finally, higher education is expected to be more visibly useful for economy and society. A third aspect of the subject that we believe must be considered, therefore, this is the relation of the social sciences to organized society, to government and industry, and other institutional centers of authority. Governments have a sense of how especially social sciences can help in the management of societies. They are also relying increasingly on the social sciences to deal with particular problems they are now facing. The UK government runs research projects on young people in urban environments and the findings of these studies have had a powerful influence on the design of government program for combating social disintegration, exclusion and unemployment. Generally speaking, the social sciences will yield more influence in the management of public affairs and will find their proper role when the right conditions exist for democratic and informed debate at every level, whether national or local. Still, the circumstances in which the social sciences have been integrated into political debate vary from country to country, although numerous recent initiatives have been influenced by a desire to bring researchers and users closer together. The Canadian government has, for example, set up a national network of centers for research into issues like immigration, with the close co-operation of local authorities, immigration services and other concerned bodies. And Sweden has launched an important program that involves the social sciences in the question of sustainable development, and which expressly provides for in-depth consultations between researchers and civil society. On the other hand, there is however also a significant feeling among social scientists that the relationship has become altogether too close. The social sciences, it is said, must maintain their distance, their freedom, from bureaucratized government and industry. Otherwise they will lose their inherent powers of honest and dispassionate criticism of the ineffective or evil in society. Although there may be a certain amount of feeling ranging from the naïve to the politically revolutionary in such sentiments, they cannot be taken lightly, as is apparent from the serious consideration that is being given on a steadily rising scale to the whole problem of the relationship between social science and social policy. In the next section, these criticisms will be discussed in more detail.

2.5 Concluding remarks

Science systems are said to be in transformation. Last two decades various studies have pointed to a variety of changes, such as an increasing orientation of science systems towards strategic goals (Irvine and Martin, 1984) and the production of relevant knowledge (Böhme et al. 1983; Gibbons et al., 1994). Especially the Mode 2 diagnosis is popular, visible and contested, although not unique. Hessels and van Lente (2008), for one, distinguish between seven alternative diagnoses, which nearly all pay attention to the changing research agenda and the increasing interaction between science and other social actors. In section 3, we will focus

especially on the weaknesses that are brought to light by their comparison in order to find further support for our analytical model, which is in essence based on the three-division described above. At the same time, we take a closer look at the attributes of Mode 1 and Mode 2 knowledge production and try to translate them in such a way as to fit our own model. By doing this, we not only hope to find theoretical underpinning for our model and references to the sociological theory, but we also try to take into account the criticism of Hessels and van Lente (2008), especially with regard to the lack of empirical evidence for the rising importance of the attributes of Mode 2 (Godin, 1998; Weingart, 1997; Hicks and Katz, 1996), the apparent incorrectness of the long-term historical perspective (Etzkowitz and Leydesdorff, 2000; Rip, 2000; Pestre, 2003), the fact that the universality of the claims is not justified (Tuunainen, 2005; Albert, 2003; Shinn, 2002), and coherence of the concept is questionable (Rip, 2002) for a further strengthening of our model.

3. New production of knowledge and attributes of knowledge production

3.1 Introduction

In the decade since its launch, *The New Production of Knowledge* (Gibbons et al., 1994) by means of its 'Mode 2' concept has gained an enormous visibility in the reflection on contemporary scientific practice. According to Hessels and van Lente, the notion of 'Mode 2' is referred to in over 1000 scientific articles and seems to have been influential for science, technology and innovation policies. Mode 2 is useful in that it highlights a number of important trends in science systems that require further empirical efforts, but there is also critic dealing with the concepts' conceptual problems. It is for this reason that they call for a separate investigation of its five major constitutive claims. In this section, we will discuss these five main attributes of Mode 2 as well as the attributes that are assigned to Mode 1 knowledge production. Next, we will look in more detail at the seven major weaknesses of Mode 2 that their research stipulates. On the basis of this information, we introduce our practical research framework consisting of information deducted from 22 interviews with SSH experts in the field of academics, business and policy, by means of which we hope to tackle some of the most important weaknesses of Mode 2.

3.2 Attributes of Mode 1 and Mode 2 knowledge production

In Table 1, representation is shown of the distinction made by Gibbons and al. (1994) between Mode 1 knowledge production, which has always existed, and Mode 2 knowledge production, a new mode that is emerging next to it and is becoming more and more prominent. According to Hessels and van Lente, the five (or ten) main attributes of Table 1 show how Mode 2 differs from Mode 1. First, Mode 1 knowledge is generated in an academic context, whereas Mode in a context of application. This does not mean that Mode 1 knowledge cannot result in practical applications, but these are always separated from the actual knowledge production in space and time, a gap that can only be closed by a knowledge transfer. In mode 2, such a distinction does not exist. Secondly, there is a difference between Modes 1 and 2 in matters of disciplinarity. Transdisciplinarity goes beyond interdisciplinarity in the sense that the interaction of scientific disciplines is much more dynamic. Transdisciplinarity, here, refers to the

mobilization of a range of theoretical perspectives and practical methodologies to solve problems, which cannot be easily reduced to disciplinary parts once theoretical consensus is contained. In the third place, a distinction is made between homogeneity and heterogeneity. In contrast to Mode 1, Mode 2 knowledge is produced in a diverse variety of organizations, resulting in very heterogeneous practice. So, besides the traditional universities, institutes and industrial labs, the range of potential sites for knowledge generation also include research centers, government agencies, think-tanks, high-tech spin-off companies and consultancies. Fourthly, autonomy is in Mode 2 replaced by reflexivity. Compared to Mode 1, Mode 2 knowledge is rather a dialogic process and has the capacity to incorporate multiple views, which relates to researchers becoming more aware of the social consequences of their work (i.e., social accountability). Finally, in Mode 2 novel quality control is used besides traditional quality control. Traditional discipline-based peer review systems are supplemented by additional criteria of political, social or cultural nature, which has as its downside that it becomes more and more difficult to determine 'good science' since this is no longer limited to the judgment of disciplinary peers.

Table 1 Attributes of Mode 1 and Mode 2 knowledge production

Mode 1	**Mode 2**
Academic context	Context of application
Disciplinary	Transdisciplinary
Homogeneity	Heterogeneity
Autonomy	Reflexivity/ social accountability
Traditional quality control (peer review)	Novel quality control

Source: Hessels and van Lente (2008)

3.3 Weaknesses and alternative approaches

Hessels and van Lente introduce a set of competing approaches that study changes in the science system in order to show that the individual elements of the Mode 2 diagnosis are not unique. The content of the various accounts all share with the Mode 2 concept a turn towards more relevant research, and more interactive relationships between science, industry and government, which suggests that these observations are correct. However, the scope of the Mode 2 diagnosis is especially wide, leading undoubtedly to weaknesses in the approach. Since the criticism found in scientific literature is very diverse, Hessels and van Lente have identified seven recurring objections: quality control; generality of Mode 2 notion; the long-term historical perspective; the coherence of the concept; theoretical underpinning; implicit support of trends; and lack of future outlook. Quality control constitutes probably the most controversial attribute of Mode 2 knowledge production, and entails the discussion about whether scientific criteria are still the most important quality control (Godin, 1998), or if a shift is taking place from quality control to quality monitoring, which is subject to influences of industry and policy, includes new peers (users, consultants, lay persons) and shows greater consideration of ethical and political issues (Hemlin and Rasmussen, 2006). So far, the importance of additional quality criteria at universities is contested and remains a question open for empirical investigation. Second, scholars point to limitations in the empirical validity of the Mode 2 approach on a more generic level. They believe that the features of Mode 2 are limited to a fairly small sector of the entire science system (Weingart, 1997; Godin, 1998). Godin (1998) further adds that SSH have always been of Mode 2, much more than has been the case for the natural and physical sciences.

Although this is contested by Albert (2003), who has shown that there is no observable trend towards Mode 2 in the sociology and economics department of two Canadian universities, basing himself on interviews with scientists and a study of their publications. Together with various other scholars, Shinn (2002) also argues that scientific disciplines and specialties operate differently in different national institutions. In relation to this generic limitation, several academics (Rip, 2000; Etzkowitz and Leydesdorff, 2000) claim that at least some of the attributes of Mode 2 knowledge production have always been present in modern society. Fourthly, Gibbons et al. (1994) imply that the notion of Mode 2 is coherent in the sense that various attributes mutually correlate. Critics seriously question this assumption, which gives rise to the idea that the claim about the rise of Mode 2 should be divided into five different claims about five distinct trends in contemporary science. The fifth limitation deals with the lack of theoretical underpinning of the book's sociological framework (Shinn, 2002). This criticism seems especially true for its lack of historical underpinning. Sixthly, several academics complain that readers of the *The New Production of Knowledge* may conclude that the old system and the old academics are wrong and that a new type of research would be better than traditional academic research (Godin, 1998). Here, the authors seem to implicitly support the observed trends. Finally, Weingart (1997) accused Gibbons et al. of not being clear with regard to the persistence of Mode 1 knowledge production. The book lacks a proper future outlook.

3.4 Towards a new knowledge production research framework

In our research, we will take the first four limitations put forward by Hessels and van Lente as our starting point. In line with the Mode 2 concept and the set of competing approaches, we support the claim that the content of scientific research agenda is currently changing, and that there is a turn towards more relevant research, i.e. research that may lead to application in the form of innovations or policy. Taking into account the lack of empirical evidence, the incorrectness of the long-term historical perspective of Mode 1 as the original type of knowledge production, the difference in dynamics in different national contexts and different scientific disciplines, and the apparent lack of coherence of the concept, we have come up with a novel framework. Most important benefits of this framework are that it: a) provides empirical evidence for the rising importance of the knowledge production attributes according to 22 experts from the academic, business and public sector in the Netherlands; b) does not make a distinction between the Modes 1 and 2, but rather uses the different attributes interchangeably; c) analyses the importance of these attributes in a specific national context, i.e. the Netherlands, and in a specific set of disciplines, namely SSH, which is considered to be Mode 2 much more than natural and physical sciences; and d) disconnects the attributes of Mode 1 and Mode 2 and investigates them separately. The attributes of Mode 1 and 2 have been changed in order to make them better understandable for interviewees who are not familiar with the terminology. Table 2 shows the set of eight alternative attributes of knowledge production that we have come up with on the basis of the Mode 1 and Mode 2 approach, and the outcomes of the 22 interviews. Due to the semi-structured design of the interviews, sometimes more attributes were discussed and sometimes there is only a focus on a few attributes, depending on the background of the interviewee. The eight attributes selected, however, are most-favored among the interviewees. Fundamental research, methods and techniques, publication system and the university as a primarily educational institution can in this respect be regarded as belonging to Mode 1. Of course, we make this distinction here purely for explanatory reasons, since the individual trends will be

addressed separately. Already, the distinction is questionable, because the attribute methods and techniques, for example, is mentioned by most interviewees as a novel approach within the SSH that would help to improve the image of SSH especially among other more scientific disciplines. Fundamental research and publication system, however, are overall considered to belong to the traditional academic context and to represent a traditional quality control. There are also interviewees who particularly mention the role of the university as being primarily educational. In most cases, they used this argument to oppose against a further commercialization of the university and for this reason we regard it as belonging to the traditional academic context. Applied research, interdisciplinarity, public-private partnerships and research valorization, then, are used by the interviewees as representing a change in the content of the scientific research agenda and a turn towards more relevant research. They may, therefore, be seen as Mode 2 attributes rather than Mode 1 knowledge production.

Table 2 Alternative attributes of knowledge production and their assignment to Mode 1 or Mode 2

Alternative attributes	**Mode 1 or Mode 2**
1 Fundamental research	M1
2 Applied research	M2
3 Methods and techniques	M1
4 Interdisciplinarity	M2
5 Public private partnerships	M2
6 Research valorization	M2
7 Publication system	M1
8 Educational focus of university	M1

3.5 Putting theory into practice

In the next section, our aim is to explore the relevance of the attributes described in Table 2 in relation to the three future movements of SSH that have been described in the first section of this paper. In this way, we not only hope to gain insight into what future development Dutch experts predict for SSH, but we also want to find out whether the different experts show a preference for a specific set of attributes and, consequently, for a specific Mode. Hopefully, this will give us further insight into the 'recognizable cognitive and organizational stability' of Mode 2, i.e. if there is a reason to distinguish between a Mode 1 and Mode 2 and to qualify Mode 2 as better than Mode 1 in this particular case. For this purpose, we will use a meta-analytical procedure, called rough set analysis, which has the appealing feature that it allows to tackle different and less immediately tangible aspects of the particular problem examined. In the next section, we will discuss the rough set approach in more detail as well as present our most important results. An interpretation of the results and its implications for the analysis of future knowledge production will be discussed in the final sections.

4. Rough set analysis of qualitative movements in SSH

4.1 Introduction

In our study, we employ an analytical artificial intelligence method called rough set analysis. Rough set analysis is a statistical tool that is most often employed in social psychology and in medical and natural sciences and to a lesser extent in the areas of SSH. We apply meta-

analysis here in order to offer a valid contribution to guaranteeing better transparency in Mode 1 and Mode 2 judgments, by reducing the level of subjectivity as well as providing a necessary condition and appropriate tool to develop a suitable framework for evaluation and assessment in the knowledge production field. Besides, as applied field work is expensive and time-consuming, in modern artificial intelligence techniques researchers often resort to low sample methods, in which a selected set of representative objects is carefully investigated by means of non-parametric methods (van Geenhuizen en Nijkamp, 2005). We have also employed an inductive approach, using a limited number of carefully selected interviewees. This approach allows 'replication', i.e. allowing the individual interviewees to represent a specific group of stakeholders (Yin, 1994), which in turn allows a close correspondence between theory and data, a process in which the emergent theory is grounded in, or in this case challenged by, the data (Eisenhardt, 1989). The rough set approach used here allows, through the application of systematical statistical methods, to pull together different knowledge production attributes in order both to extract and organize these attributes and to focus on common elements, success factors and impediments in future movements of the knowledge production systems. In this section, after a further description of rough set approach, the design and outcomes of our analysis will be presented.

4.2 Rough set analysis

Conventional statistical analysis, such as multiple regression analysis or discrete choice modeling, could not be applied in our study because of the qualitative nature of the variables. Therefore, we have made use of another technique that has received increasing attention in the recent past, i.e. rough set analysis (see e.g., Pawlak, 1991; Polkowski and Skowron, 1998). Rough set analysis classifies the available information in classes of attributes and in this way can discover possible cause-effect relationships from a set of data in order to pursue a more structured and precise knowledge (Nijkamp, 1996). The results from the semi-structured interviews were systematically codified in a database as a matrix that constitutes a concise representation of the underlying field information. This multi-attribute table served as a basis for a systematic comparison of the future movements of SSH in the Netherlands and knowledge production factors influencing these movements. A rough set, here, is a set for which the classification of a group of certain objects is not entirely certain. The reason is that the classification of specific categorical data is dependent on the measurement scale (the degree of 'granularity'). Of course, we have to assume that there is a finite set of objects to be classified. Information on these objects, i.e. in this case the 22 experts, is collected by assigning features of these objects to distinct relevant classes. In this case we have used a limited set of characteristics, i.e. sector, educational background and current profession, as features or rather attributes. These attributes are used to further define the relationships between the set of knowledge production attributes and the response variable, i.e. future developments of SSH (see for an overview Table 3). In this way, equivalence classes can be identified. Objects belonging to the same equivalence class are 'indiscernible'. Further, a 'core' can often be identified, which consists of the class of all indiscernible equivalence relationships. Attributes in the core may be seen as the critical variables in an exploratory sense. Rough set analysis is thus essentially a classification experiment. It aims to identify under which conditions certain attributes are necessary to explain the existence of a response variable. The results are usually of an if-then nature and go by the name of 'decision rules'. A useful computer software programme to carry out rough set analysis

is Rough Set Data Explorer (ROSE), an open source programme that can be retrieved free of charge via the internet. This algorithm constructs the best possible decision rules to explain the frequency of occurrence of features (van Geenhuizen en Nijkamp, 2005). As a result, rough set analysis is able to face two particular issues of the decision-making context: 1) it provides an *explanation*, i.e. is capable to point out the critical aspect of the problem and the correlation between the data, by resorting to a set of conditional attributes and an information table, and 2) it provides a *prescription*, i.e. is capable of evaluating the information available in a decision table, aiming to provide a comprehensive preference model as a support in the decisional and negotiation process (Nijkamp, 1996). We will now apply this approach to a comparative analysis of the eight knowledge production attributes, aiming to identify dominant patterns which may be useful for understanding movements in SSH.

4.3 Results of the analysis

Main goal of our analysis is the discovery of relevant subsets of knowledge production and spillover in the Netherlands according to the 22 experts interviewed, as well as a representation of all important relationships between the characteristics of the interviewees and their ideas about the future development of social sciences and humanities knowledge production. We are particularly interested in the question: what development in the social sciences and humanities do the Dutch experts predict for the near future? Will there be a focus on further differentiation, on further synthesis, or will there be an ever closer relationship of SSH with organized society, government and industry, and other institutional centers of authority? And what knowledge production forms are necessary to achieve this development? We distinguish between the following forms of knowledge production: 1) fundamental research, 2) applied research, 3) methods and techniques, 4) interdisciplinarity, 5) public-private partnership, 6) research valorization, 7) publication system, and 8) university as a mere education institution (Table 3). These knowledge production forms, then, can act as success factors in our analysis or as impediments. In order to better interpret the results, we further discriminate between objects' characteristics. Focus of our analysis is on the characteristics 'type of sector', 'educational background' and 'current profession', which are in turn subdivided into different classes (see Table 3). Differentiation, synthesis and paradigm are the decision attributes. Using the computer software program ROSE, we find 12 rules that predict something about the future movement of SSH, which is further explained in Table 4.

Table 3 Representation of the RSA decision table

Objects	**T**	**E**	**P**	**S**	**I**		**D**
1	1	2	2	4	5		3
2	2	2	2	6	6		3
3	4	2	1	6	6		3
4	4	4	2	6	6		1
5	4	7	3	4	6		2
6	2	1	2	4	5		2
7	4	2	2	4	6		1
8	4	6	1	2	6		2
9	4	5	2	6	6		1
10	1	2	1	1	7		2
11	4	3	1	4	7		3
12	1	1	2	4	6		3
13	4	2	1	5	6		3
14	4	2	1	2	6		3
15	2	4	2	4	6		2
16	4	4	3	4	6		2
17	4	2	3	1	2		1
18	3	3	3	1	2		1
19	4	2	2	5	6		1
20	4	2	2	5	6		1
21	5	2	1	2	8		3
22	3	2	3	2	7		3

Condition and decision attributes	
T: Type of sector	**S: Success factors**
Classes: 1 research 2 business 3 media 4 public 5 other	Classes: 1 fundamental research 2 applied research 3 methods and techniques 4 interdisciplinarity 5 public private partnerships 6 research valorization 7 publication system 8 educational focus
E: Educational background	**I: Impediments**
Classes: 1 humanities 2 social sciences (incl. economics and psychology) 3 earth and life sciences 4 combination of social sciences, humanities and earth and life sciences 5 medical sciences 6 agricultural sciences 7 other	Classes: 1 fundamental research 2 applied research 3 methods and techniques 4 interdisciplinarity 5 public private partnerships 6 research valorization 7 publication system 8 educational focus
P: Profession	**D: Future developments***
Classes: 1 research 2 management 3 other	Classes: 1 differentitation 2 synthesis 3 paradigms

* Decision attribute

Table 4 shows the influence of objects' characteristics and knowledge production forms on the future movements in SSH. Both the accuracy and the quality of the rough set approximation equal 1, meaning that the reliability of the classification for the dependent variable, i.e. the future development of SSH, and the overall quality are at their maximum. Not all condition variables, however, belong to the core. Only education and profession reassigned to the core with a quality of 0.273, meaning that these two condition variables explain 27.3% of the choice of interviewees for a particular future movement of SSH. Rule 1 has the highest decision coverage, namely 71.43%, which means that for 71.43% of the interviewees that showed a preference for further differentiation this rule is true. Rule 1 indicates a preference of interviewees from the public sector for further differentiation of SSH in the near future. An explanation for this may be that all interviewees that show a preference for this development work in a public institution that focuses on a specific area of SSH, like sustainable development or urban policy. Due to the semi-structured design of the interviews, focus is often on their specific field of expertise. Interviewees working outside the field of research, so working in for example the public or business sector, often brought up their inability to answer questions about characteristics of SSH and future developments that were too specific, since this requires knowledge about university systems and operational procedures. The experts that showed a preference for further differentiation that did have a better insight into these systems and processes, particularly highlighted the negative effect of a too strong focus on applied research for SSH (rule 2). Interviewees that prefer further synthesis have an educational background in social sciences, humanities and earth and life sciences (rule 3). It should be noted here that in both cases it concerns interviews with two experts. So, actually, four people are interviewed in the case of rule 3, although this cannot be marked as such, because of the interwovenness of their responses. Surprisingly, both duos link the positive effect that they believe interdisciplinarity has on SSH to a further synthesis of SSH in the near future. The only interviewee in the private sector that shows a preference for further synthesis of SSH considers in particular public private partnerships as an impediment (rule 6). This interviewee regards the academic and business sector as two separate entities that do not mix well. This expert, as a result, prefers further synthesis rather than a greater societal role for SSH. Finally, fundamental research is also positively associated with further synthesis (rule 7). Fundamental research is increasingly conducted in interdisciplinary research teams in the public knowledge institution that this interviewee represents. The central idea behind this development is that further complexity of society requires a more interdisciplinary approach of fundamental issues. Paradigms, i.e. a closer relationship of SSH with society, government and industry, and other institutional centers of authority, is especially interesting for those interviewees from the public sector who have a research position, and have a educational background in social sciences (rule 8). Similar to the interviewees of rule 1, these experts also work in public institutions, but different from the first they work specifically in a research institution or research department and also often (still) have strong links with universities. Due to this they overall tend to have a stronger opinion about the future of SSH and are better able to answer questions that more specifically deal with systematic issues related to SSH. Rule 9 further shows that three interviewees that share an educational background in social sciences believe that a further development towards stronger interaction between society, business and public sector positively correlates with attention for applied research in SSH. Experts with a management function in a university setting also promote closer relationship of SSH with society, government and industry, but focus especially on further interdisciplinarity (rule 10). The current publication system is further seen as an impediment for

achieving a larger societal role (rule 11), while research valorization is especially interesting for the business sector (rule 12).

Table 4 Outcomes of the rough set analysis

Conditions	**Strength of rules**	**Objects' characteristics**	**Generalization**
Rule 1. T=4, P=2 / D=1	71.43%	Working in the public sector in area of management	**IF** applied research is considered an impediment **THEN** interviewees predict further differentiation of SSH
Rule 2. I=2 / D=1	28.57%		
Rule 3. E=4, **S=4** / D=2	33.33%	Educational background in agricultural studies, social sciences, humanities, earth and life sciences or other, and active in the research sector	**IF** public private partnerships are considered an impediment, and fundamental research and interdisciplinarity success factors **THEN** interviewees predict further synthesis of SSH both within SSH and between SSH and other disciplines
Rule 4. E=6 / D=2	16.67%		
Rule 5. E=7 / D=2	16.67%		
Rule 6. E=1, **I=5** / D=2	16.67%		
Rule 7. T=1, **S=1** / D=2	16.67%		
Rule 8. T=4, E=2, P=1/ D=3	33.33%	Educational background in social sciences, earth and life sciences, and working in the research, business or public sector, and research as a profession	**IF** the publication system is considered an impediment, and interdisciplinarity and research valorization a success factor **THEN** interviewees predict a closer relationship of SSH with society, government and industry, and other institutional centers of authority
Rule 9. E=2, **S=2** / D=3	33.33%		
Rule 10. T=1, **S=4** / D=3	22.22%		
Rule 11. E=3, **I=7** / D=3	11.11%		
Rule 12. T=2, **S=6** / D=3	11.11%		
Accuracy of classification		1.0000	
Quality of classification		1.0000	
Core set		Education and Profession	
Quality of core		0.2727	
Strength of rules		Rule 1. (71.43%) relevant for 5 interviewees Rule 3. (33.33%) relevant for 2 interviewees Rule 8. (33.33%) relevant for 3 interviewees Rule 9. (33.33%) relevant for 3 interviewees	

Table 5 shows the relation between the different knowledge production factors and the future developments in SSH in more detail. There are seven interviewees who generally predict a further differentiation of SSH. Focus is in this case solely on the negative effect that applied research can have on SSH. According to these experts, SSH are primarily a collective of different academic disciplines that each have their own strengths and weaknesses. Sometimes disciplines will become so marginal that they will disappear, but societal changes can also increase popularity of disciplines or create a need for new disciplines. One interviewee, for example, mentioned the increased popularity of Arabic studies after the 9/11 attacks. But overall,

the experts in favor of differentiation are for a continuation of the current situation, whereby the academic character should not be challenged by a too strong focus on applied research. Further, six interviewees predicted synthesis as a future development for SSH. Fundamental research and interdisciplinarity can in this respect be seen as success factors, whereas public-private partnership acts as an impediment. The experts that have opted for further synthesis are, in line with those that chose differentiation, of the opinion that the academic character of SSH should be central, but different from the first group believe that interdisciplinarity is very important and should be promoted. Interviewees in favor of paradigms, then, support the growing influence of interdisciplinarity on SSH research. They also believe, however, that research valorization will strengthen SSH in the near future. A closer relationship of SSH with society, government and industry is favored, because most interviewees view SSH as the ideal link between science and society. The ever-increasing complexity of society requires both an academic viewpoint in order to better understand the social issues at stake, as well as a more interdisciplinary view on scientific questions. With regard to the latter, there is a growing belief that technological innovations, environmental problems, etc. cannot be solved properly without taking into account the social[1] implications.

Table 5 The effect of knowledge production functions on future developments in social sciences and humanities

	Differentiation	**Synthesis**	**Paradigms**
1. Fundamental research		+	
2. Applied research	-		
3. Methods and techniques			
4. Interdisciplinarity		+	+
5. Public-private partnerships		-	
6. Research valorization			+
7. Publication system			-
8. University as educational institution			
Total interviewees	**7**	**6**	**9**

5. Conclusion

Aim of our analysis was to answer two main questions: what development in the social sciences and humanities do representative Dutch experts predict for the near future; in particular, will there be a focus on further differentiation, on further synthesis, or will there be an ever closer relationship of SSH with society, government and industry, and other institutional centers of authority? And what knowledge production forms are necessary to achieve this development? Basically, what the results of the rough set analysis show us is that, even though, on first sight differentiation, synthesis and paradigm have a more or less equal chance of impacting SSH in the near future according to the interviewees, if we look closer at the results we see a strong preference among the majority of interviewees for further interdisciplinarity. This also brings to

[1] Social is here used in a broad sense, so including social, economic, historic, linguistic, and so on.

the surface the subdivision between those experts who regard SSH as a purely academic affair and those who promote a stronger interaction between SSH and society, government and industry. From our results, it appears that the first group is larger, namely 13 against 9 interviewees. Surprisingly, the group that prefers a predominantly academic role for SSH does not consist solely of experts active in a university setting, on the contrary especially the research and university experts promote a larger societal role for SSH. Interestingly, in this respect the divide seems driven largely by competitive behavior. The experts that are in favor of a primarily academic role for SSH work predominantly on specific social issues in public or private institutions, so they experience a direct benefit from a strict academic role for SSH, because this insures their impact in the work field. A larger role for SSH may be viewed as competition. A similar interpretation seems true for those experts that promote a larger societal role for SSH, even more so, because in this case we deal with experts active largely in universities and research institutions. These experts are aware of a growing role for social and societal institutions either initiated by the public sector or the private sector, and may fear a knowledge take-over. On top of this, they may feel threatened by for example technical and biotechnical disciplines, because contrary to these disciplines SSH is not so easily able to valorize research. A greater societal role may therefore serve as a form of valorization for SSH and show its usefulness as a discipline to a larger public.

6. Implications

Having taken into account the heterogeneity of science, paying attention to the differences between scientific fields and national contexts in our analytical model, our research supports the suggestion made by Hessels and van Lente (2008) to regard the individual attributes of the Mode 2 concept as separate trends rather than as characteristics of a general development. In line with the literature discussed in their paper, our analysis shows that not all ‘Mode 2’ attributes simultaneously correlate in our analysis, nor do the ‘Mode 1’ attributes. Only in the case of paradigms are several, though not all, Mode 2 attributes regarded as success factors, and is publication system, a Mode 1 attribute, considered an impediment. Further, only interdisciplinarity is regarded as having an overall positive influence on the future of SSH according to a majority of the Dutch experts. The preference for this attribute may be explained by the fact that this knowledge production feature is academic enough not to be a threat to the traditional research system, and innovative and even commercial enough as to not lead to a lock-in. A situation that emerged during the 1950s and 1960s (Rip, 2000). This does not mean that the interviewees do not support the claim that the content of the scientific research agenda indeed is changing, but there seems to be a lot of misunderstanding between the different sectors on the desirability of these changes that at the moment seem to be blocking the way for an actual answering of the empirical questions as posed by Hessels and van Lente in their conclusion (read: solution). Our analysis merely indicates that in the Netherlands there seems to be a preference for interdisciplinarity in the areas of SSH over other knowledge production functions in the near future. It does not indicate whether this already constitutes a substantial part of contemporary science systems. At the same time, the outcomes do show a minor preference for paradigm, which may indicate a development of interdisciplinarity towards transdisciplinarity, but this is mere speculation. The rough set analysis, however, does seem to provide an answer to the second question insofar that most experts working in a university or research institution with close links to the university predicted a closer relationship of SSH with organized society,

government and industry, and other institutional centers of authority. This gives us reason to believe that university scientists in the Netherlands are increasingly reflexive. Finally, the third question is outside the scope of our paper. We have only included publication system as a type of scientific quality control, which is a traditional form of quality control. Interestingly, though, this system is, especially with experts in favor of a larger societal role for universities, seen as an impediment. This does indirectly predict a larger future role for new criteria, relating to the societal relevance of research results, in scientific quality control for SSH in the Netherlands.

7. Limitations and ways forward

Several restraints with regards to our rough set analysis need to be taken into account that can seriously prejudice the outcome of the evaluation approach. In our case, for the interpretation and codification of the results of semi-structured interviews objectivity cannot be guaranteed. Although we have been careful to include all knowledge production attributes referred to by the experts, for matters of comparability in some cases attributes have been excluded from our analysis. We have to assume that there is a finite set of data that can be incorporated in the analysis. Also, the information matrix does not allow for multiple codification, so in several interviews it was necessary to select between attributes or future movements. The semi-structured design of the interviews further complicated objective codification in this respect. There is a need to distinguish between people who are strongly involved in the whole discussion about SSH and those who are not and who view the subject from their specific and specialist field of expertise. This clearly affected the richness and structure of these interviews as well as the objectivity towards the issue from the side of the interviewee. With the inclusion of the objects' characteristics into the model, we however hope to have tackled this limitation to some extent. Finally, the interviews were primarily conducted for the EU 6th Framework Project SSH-Futures and have been introduced as such to the interviewees. Experts questioned have, as a result, not answered the questions with the specifics of Mode 2 concept in mind, although focus of the project is also on SSH futures and different perspectives that exist about SSH research. We therefore believe the results of our analysis are valid.

One of our aims was to add to the discussion on science systems and its future in order to offer further transparency to policy makers. Our most important finding is that, on the basis of our exploratory analysis, the idea of a clear distinction between Mode 1 and Mode 2 knowledge production can be rejected. The suggestion that elements of Mode 2 have always existed in modern science is in this respect not necessarily supported, but has certainly gained plausibility. This realization is important in the light of the current discussion, which runs the risk of turning into deadlock. Curiosity-driven research and use-driven, i.e. the desire to seek new understanding and knowledge about nature and the desire to use that knowledge in a practical way, appear to be naturally co-existing and in closely interaction. Due to this, characteristics of Mode 1 and Mode 2 are better regarded as separate trends rather than as characteristics of a general development, shedding further light on the nature of the discussion about SSH and the science system in general. Higher education may feel itself under pressure to cope with a growing range of expectations that are viewed as demanding; the pressures, however, appear far less conflicting than originally assumed. For the Netherlands science system this implicates that the tensions that currently exist in the Dutch academic field seem for a large part based on 'false' assumptions. In the case of the Netherlands' science system, this is largely caused by a lack of communication

between the different disciplines, which in turn appears largely due to the strong autonomy that exists within the Dutch university system. There is a large fragmentation in the Dutch science system that seems to hamper communication and, for that matter, interdisciplinarity, which may serve as a further explanation for the strong emphasis on this attribute by the Dutch experts. Interestingly, the latter observation leads us to conclude that the Dutch science system is slowly opening up for closer cooperation between the different disciplines and, with that, perhaps also closer cooperation between the faculties and even universities. The growing presence of interdisciplinary research centers in the Netherlands only supports this view. Transdisciplinarity, however, is in this respect still in the future for the Netherlands. There are clear signs that similar opposing scenes are also apparent in other European countries. Further research into country differences needs to be conducted to show more definite results, even though, due to the large differences in science systems in the different EU countries, such research is challenging.

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